The effect of dietary restriction on productive and microbial traits of broiler chickens

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Abstract

This study aimed to determine the effect of dietary restriction on certain production and microbial traits of broiler chickens. A total of 210 one-day-old, unsexed Ross 308 commercial hybrid chicks, with an average initial weight of 40 g, were used in the study. The experiment was divided into seven experimental treatments, each consisting of 30 birds, with three replicates per treatment (10 birds/replicate), yet. The final results of the experiment showed a highly significant improvement (P≤0.01) in final body weight and weight gain, as well as a significant difference (P≤0.05) in feed consumption and overall feed conversion efficiency and production index values. Additionally, a considerable superiority (P≤0.05) was observed in the dressing percentage and the logarithmic counts of Lactobacilli bacteria, along with a significant decrease in E. coli bacteria across all restricted treatments when compared to the control treatment. Treatments T3 and T2 achieved the best results among the restricted treatments.

Keywords: Feed Restriction, Regulated Nutrition, Broiler Chickens

Introduction

The broiler chicken industry, known as the broiler industry, is currently considered a significant sector. The poultry sector is one of the fastest-growing areas of agriculture, primarily due to developments in both developed and developing countries[1]. This progress is expected to continue in the coming years due to the increasing global demand for poultry meat, given its high nutritional value. The poultry industry is regarded as one of the main pillars of the economies of many countries worldwide due to the importance of its products in nutrition, high sales, and rapid returns on investment, in addition to the palatability of its products for human consumption [2].

Hybrid broiler chicken breeds are characterized by rapid growth and high feed conversion efficiency, achieving a weight gain of 1 gm with a feed consumption of 1.47 grams, compared to the previous rate of 1 gm of weight gain with a feed consumption of 2 grams[3]. However, substantial economic losses due to high mortality rates resulting from sudden death syndrome, ascites, metabolic issues, and skeletal problems are suffered by poultry projects [4,5].Due to the negative correlation between growth rate and immune response being one of the main and significant reasons [6].

Most research and studies have focused on finding ways to slow growth rates in the early stages to enhance poultry immunity and reduce metabolic issues, sudden death syndrome, and ascites through dietary restriction programs. This is considered an important dietary system for broiler chickens and can take various forms: quantitative, where the daily feed amount is controlled; qualitative, where the protein and energy ratios in the diet are regulated; or temporal, where feed is provided for specific periods and chickens are fasted for one day at a time. It may also involve reducing the diet to include high-fiber materials such as wheat bran, oats, sand, dates, and olive pomace, or light restriction by controlling daily exposure to light. The physical methods involve reducing the diet with high-fiber materials such as wheat bran, oats, sand, or date and olive pomace, as well as light restriction by controlling daily light hours, while the chemical method involves adding organic compounds that suppress the birds' appetite [4, 5, 6, 7, 8]. Restricting the feeding of broiler chickens at an early age can improve vascular function by increasing blood vessel density. This enhances the amount of oxygenated blood and improves metabolic processes, leading to better feed conversion efficiency [9]. Restricted feeding in the early stages of life in broiler chickens may modify metabolic processes, improve production performance, and increase the concentration of the metabolic hormones T4 and T3 in the thyroid gland, which are the main factors in increasing the feed consumption rate and improving feed conversion efficiency and body weight gain. The rapid adaptation of broiler chickens to formulated diets, resulting in final weights that are similar to or exceed those achieved through free-range feeding, is achieved through complete compensatory growth [6].

The aim of using early dietary restriction programs for broiler chickens is to mitigate the negative effects of ad libitum feeding on production performance and microbiota. Therefore, our study aims to investigate the impact of early dietary restriction on certain production and microbiological traits of broiler chickens.

Materials and Methods

Experimental Design

The experiment aims to study the effect of early dietary restriction on the productive and microbial traits of broiler chickens, achieved by increasing feed and adding wheat bran.

The study was conducted in the Poultry Hall for Studies and Research. This is affiliated with the Animal Production Department. The department is at the College of Agriculture, University of Karbala. The study was conducted from 7 October 2024 to 18 November 2024. A total of 210 one-day-old Ross 308 broiler chicks, averaging 40 grams in weight, were raised. The chicks were housed in a 7m × 12m hall equipped with four-tier battery cages, each tier containing cages measuring 1m × 1m. The chicks were randomly assigned to seven experimental treatments, with 30 chicks per treatment and three replicates per treatment (10 chicks per replicate). The treatments are as follows:

Treatment 1 (T1—Control): The animals were allowed to eat as much food as they wanted.

Treatment 2 (T2): The animals were allowed to eat as much food as they wanted, but they had to fast for 4 hours every day.
Treatment 3 (T3): The animals were allowed to eat as much food as they wanted, but they had to fast for 6 hours every day.
Treatment 4 (T4): The animals were allowed to eat as much food as they wanted, but they had to fast for 8 hours every day.
Treatment 5 (T5): The animals were allowed to eat as much food as they wanted, but they had to fast for 4 hours every day and also had to eat bran for 4 hours every day.
Treatment 6 (T6): The animals were allowed to eat as much food as they wanted, but they had to fast for 6 hours every day.
Treatment 7 (T7): The animals were allowed to eat as much food as they wanted, but they had to fast for 8 hours every day and also had to eat bran for 8 hours every day.

Weekly feed quantities are weighed for each replicate, and at the end of each week, the average weekly body weight and weight gain are calculated by finding the difference between the body weight in the second week and the first week, and so on. The average feed consumption is calculated by determining the difference between the weekly feed quantity and the remaining amount. Feed conversion efficiency is assessed by the ratio of the amount of feed consumed to the weekly weight gain, using a sensitive scale. At the end of the experiment, at 42 days of age, final weights were recorded, and two birds from each replicate were slaughtered to calculate the dressing percentage with and without the edible offal and primary and secondary cuts. A sample from the area where the ileum connects to the ceca was taken to determine the logarithmic counts of beneficial and pathogenic bacteria.

Statistical Analysis

The experimental data were analyzed using a Complete Randomized Design (CRD) to study the effect of early dietary restriction on the studied traits. Significant differences between the means were compared using [10]. The statistical analysis was conducted using the SAS [11]

Results and Discussion

Table (1) show that illustrates the impact of temporal dietary restriction on the average weekly and final body weight, we observe that there are no significant differences among the experimental treatments during the first week. However, in the second and third weeks, a highly significant superiority ($P \leq 0.01$) was noted for the control treatment compared to all dietary restriction treatments T7, T6, T5, T4, T3, In the fourth week, a highly significant superiority ($P \leq 0.01$) was observed for all dietary restriction treatments compared to the control treatment

In the sixth week, all dietary restriction treatments exhibited a highly significant superiority ($P \leq 0.01$) over the control treatment. The T3 dietary restriction treatment achieved the highest final weight of 2739.67 grams, while the control treatment recorded the lowest final weight of 2596.67 grams.

Table (1): Effect of time-restricted feeding from 8 to 21 days of age on weekly body weight (gm) ± standard error for broiler chickens.

Transactions	Age (weeks)					
	1	2	3	4	5	6
T1	0.88 ±145.67	5.78 ±344.67 a	3.84 ±729.67 a	11.67 ±1253.67 c	14.53 ±1792.33 d	6.00 ±2596.67 b
T2	0.76 ±146.50	4.16 332.00± b	2.30 ±708.00 b	7.42 ±1318.67 a	17.61 ±1967.67 a	11.55 ±2727.33 a
T3	0.50 ±145.50	1.76 316.67± c	7.88 ±655.33 d	9.82 ±1271.17 bc	11.54± 1924.00 b	15.60 ±2739.67 a
T4	0.67 ±139.33	3.49 ±303.17 d	7.57 ±646.00 de	10.97 ±1250.83 c	11.25± 1861.67 c	5.20 ±2616.67 b
T5	1.01 ±145.17	2.33 ±318.33 c	5.23 ±683.33 c	4.36 ±1318.50 a	4.33 ±1993.67 a	11.93 ±22725.67 a
T6	0.59 143.84±	2.96 ±321.33 bc	3.17 ±678.67 c	9.82 ±1291.33 ab	1.20 ±2001.33 a	11.25 ±2719.00 a
T7	0.67 140.33±	3.44 ±281.17 e	8.18 ±635.00 e	9.26 ±1262.33 bc	11.57 ±1916.47 b	4.70 ±2710.67 a
Morale level	NS	* *	* *	* *	* *	* *

Different letters indicate significant differences between the means of the treatments.
** This indicates significant differences at the 0.01 level. The mean ± standard error

Table (2) shows the impact of time-restricted feeding on both weekly and cumulative weight gain in broiler chickens. However, in the second and third weeks, a highly significant superiority (P≤0.01) was noted for the control treatment over all time-restricted feeding treatments. In the fourth and fifth weeks, a highly significant superiority (P≤0.01) was observed for all time-restricted feeding treatments over the control treatment. In the sixth week, a significant superiority (P≤0.01) was observed for treatments T3, T7, and the control treatment over the other restricted treatments,

Table (2): The Effect of Early Time-restricted Feeding on Weekly and Cumulative Weight Gain of Broiler Chickens

Transactions	Age (weeks)						cumulative weight gain
	1	2	3	4	5	6	
T1	1.20 ±106.33	5.50 ±199.00 a	4.04 ±385.00 a	15.34 ±522.67 c	9.38 ±538.67 e	8.45 ±804.33 a	5.03 ±2556.00 b
T2	0.17 ±108.17	3.50 ±185.50 b	5.20 ±377.33 ab	9.61 ±610.67 ab	10.96 ±649.00 c	15.93 ±759.67 b	13.56 ±2690.33 a
T3	0.76 ±107.50	2.17 ±171.17 cd	6.55 ±342.00 d	5.48 ±612.50 ab	3.76 ±652.83 bc	6.06 ±815.67 a	15.71 ±2701.67 a
T4	0.58 ±101.00	3.34 ±163.83 d	3.61 ±349.50 cd	8.62 ±604.83 b	11.11 ±610.83 d	9.50 ±755.00 b	7.93 ±2585.00 b
T5	0.76 ±106.50	1.96 ±173.17 cd	3.00 ±365.00 bc	6.39 ±635.17 a	5.26 ±675.17 ab	7.88 ±731.33 bc	12.25 ±2686.33 a
T6	0.83 105.17 ±	2.47 ±177.50 bc	1.20 ±357.33 cd	7.53 ±612.67 ab	7.53 ±695.33 a	12.42 ±718.00 c	25.53 ±2666.00 a
T7	0.58 103.00 ±	3.09 ±140.83 e	10.54 ±353.83 cd	5.78 ±627.33 ab	2.67 ±612.33 d	8.54 ±836.00 a	4.37 ±2673.33 a
morale level	NS	* *	* *	* *	* *	* *	* *

Different letters indicate significant differences between the means of the treatments.
** This indicates significant differences at the 0.01 level. The mean ± standard error:

Table (3) illustrates the impact of time-restricted feeding on the weekly and cumulative Feed intake of broiler chickens. However, in the second and third weeks, a highly significant decrease (P≤0.01) in feed intake was observed in the restricted treatments compared to the control group

In the fourth and fifth weeks, a highly significant decrease (P≤0.01) in feed intake was observed in the control treatment compared to all restricted treatments, In the sixth week, a highly significant decrease (P≤0.01) in feed consumption was noted in the restricted treatments T6, T5, T4, T3, and T2 compared to the control treatment and treatment T7

Table (3): Effect of time-restricted feeding from day (8-21) for broiler chickens on weekly feed intake (gm) ± standard error

Transactions	Age (weeks)						Cumulative feed consumption
	1	2	3	4	5	6	
T1	0.33 ±140.33	12.83 ±339.33 a	4.72 ±646.00 a	19.70 ±850.33 b	4.63 ±941.67 d	5.50 ±1379.00 a	8.29 ±4296.67 a
T2	0.29 ±138.50	3.98 ±291.17 b	10.89 ±586.33 b	10.89 ±954.33 a	14.19 ±1028.00 c	19.13 ±1241.00 bc	32.88 ±4239.33 ab
T3	0.88 ±138.33	0.58 ±281.00 bc	8.29 ±579.33 bc	12.99 ±864.33 b	17.28 ±1024.67 c	2.64 ±1262.00 b	33.98 ±4149.67 b
T4	0.93 ±139.17	0.67 ±278.67 bc	2.67 ±562.33 c	18.20 ±940.67 a	22.36 ±1006.00 c	13.34 ±1240.33 bc	25.10 ±4157.17 b
T5	0.60 ±140.83	6.24 ±267.00 c	2.89 ±570.00 bc	12.77 ±966.00 a	18.23 ±1077.00 b	15.60 ±1198.33 cd	38.16 ±4219.17 ab
T6	0.88 137.67 ±	1.86 ±291.33 b	1.76 ±565.33 c	15.60 ±933.67 a	6.55 ±1140.00 a	14.83 ±1191.67 d	30.55 ±4253.67 a
T7	1.44 ±138.50	5.24 ±242.33 d	6.35 ±563.33 c	3.50 ±936.00 a	11.39 ±992.67 c	19.85 ±1349.33 a	7.52 ±4222.17 ab
m or	NS	**	**	**	**	**	*

Different letters indicate significant differences between the means of the treatments.
** This indicates significant differences at the 0.01 level. The mean ± standard error:

Table (4) shows the effect of time-restricted feeding on feed conversion efficiency. In the second week, the treatments T5 and T2 significantly outperformed the control treatment and the other feeding treatments (P≤0.01),. In the third week, there was a highly significant improvement (P≤0.01) in feed conversion efficiency in favor of the restricted treatments T7, T6, T5, and T2 compared to the control treatment. In the fourth week, the treatment T3 achieved a significant improvement (P≤0.01) in feed conversion efficiency compared to the control treatment and the feeding treatments T7, T6, T5, T4, and T2, a highly significant improvement (P≤0.01) in feed conversion efficiency was observed during the fifth and sixth weeks for all dietary restriction treatments compared to the control treatment

Table (4): shows the effect of time-restricted feeding from day 8 to day 21 on the weekly feed conversion ratio (gm of feed/gm of weight gain) ± standard error.

Transa	**Age (weeks)**						**fee d conversio n rate**
	1	**2**	**3**	**4**	**5**	**6**	
T 1	0.018 ±1.318	0.035 ±1.704 c	0.028 ±1.677 c	0.019 ±1.626 d	0.021 ±1.748 d	0.012 ±1.714 d	0.004 ±1.632 d
T 2	0.004 ±1.280	0.013 ±1.582 a	0.009 ±1.554 a	0.023 ±1.563 c	0.012 ±1.584 ab	0.009 ±1.634 bc	0.006 ±1.533 a
T 3	0.016 ±1.286	0.023 ±1.639 bc	0.013 ±1.698 c	0.009 ±1.411 a	0.024 ±1.572 a	0.008 ±1.547 a	0.004 ±1.525 a
T 4	0.005 ±1.377	0.037 ±1.702 c	0.013 ±1.640 bc	0.039 ±1.540 bc	0.007 ±1.646 c	0.006 ±1.639 bc	0.006 ±1.591 c
T 5	0.003 ±1.323	0.020 ±1.539 a	0.007 ±1.561 a	0.003 ±1.524 bc	0.026 ±1.595 abc	0.004 ±1.630 b	0.003 ±1.528 a
T 6	0.017 ±1.308	0.031 ±1.641 bc	0.010 ±1.582 ab	0.008 ±1.524 bc	0.008 ±1.640 bc	0.008 ±1.659 c	0.008 ±1.559 b
T 7	0.021 ±1.344	0.013 ±1.725 c	0.040 ±1.594 ab	0.009 ±1.492 b	0.011 ±1.620 abc	0.007 ±1.613 b	0.005 ±1.565 b
M	NS	* *	* *	* *	* *	* *	*

Different letters indicate significant differences between the means of the treatments.
** This indicates significant differences at the 0.01 level. The mean ± standard error:

Table 5 shows the effect of rationing on the logarithmic counts of Lactobacilli and E. coli (cfu/gm), where T7, T6, T5, T2, and T3 rationing treatments outperformed the control treatment at a significant level (P≤ 05), while T3 outperformed the control. A significant decrease (P≤0.05) was observed for all rationing treatments in the logarithmic counts of pathogenic E. coli compared to the control.

Table (5): Effect of dietary rationing at the age of (8-21) days for early chickens on the logarithmic counts of Lactobacilli and E. coli (cfu/gm) of intestinal contents ± standard error.

Treatments	Lactobacilli	E. Coli
T1	0.044 ±4.04 d	0.13 ±10.85 a
T2	0.111 ±5.91 b	0.04 ±8.78 e
T3	0.072 ±6.28 a	0.06 ±8.43 f
T4	0.043 ±4.25 d	0.06 ±10.06 b
T5	0.043 ±5.74 b	0.06 ±9.06 d
T6	0.037 ±5.36 c	0.05 ±9.23 CD
T7	0.116 ±5.146 c	0.04 ±9.43 c
morale level	*	*

Different letters indicate significant differences between the means of the treatments.
** This indicates significant differences at the 0.01 level. The mean ± standard error:

The results in tables (1,2) indicate that the control treatment outperformed all dietary restriction treatments in terms of body weight and weight gain during the second and third weeks, with varying percentages. This is expected due to the increased feed during the dietary restriction period and the limited time intervals, as well as the decreased rate of feed intake. Additionally, the decrease in body weight and weight gain for the dietary restriction treatments is attributed to the specified amounts of feed over time, which affects growth and weight gain rates. This has been noted by several researchers, including [12,13,14,15,5], who reported a decrease in weight body and weight gain rates of broiler chickens under restricted feeding during the dietary restriction period due to lower amounts of feed consumed during that time. However, after the end of the dietary restriction period and the onset of ad libitum feeding in the fourth, fifth, and sixth weeks, a highly significant superiority ($P \leq 0.01$) was observed for the restricted treatments T7, T6, T5, T3, T2 over the control treatment T1 in body weight and weight gain. This is attributed to an increase in feed consumption rates and improvements in feed conversion efficiency, as shown in Tables 5, 6. This is attributable to the increase in feed consumption and improvement in feed conversion efficiency, which leads to enhanced growth and benefits from compensatory growth. This superiority is attributed to the achievement of complete compensatory growth in all time-restricted dietary treatments, as it is possible to achieve complete compensatory growth after the end of the dietary restriction period when the duration of ad libitum feeding is 20 days or more [17,18,19,5].

We observe from Tables (3,4) a significant superiority of the control treatment in the rate of feed consumption over all the regulated treatments, with a decrease in feed consumption during the second and third weeks of the regulated treatments at the beginning of the implementation of the dietary regulation program with specific time intervals. This negatively affected growth, body weight, and weight gain rates, which is a natural outcome due to the increase in feed during that period and at specific times, leading to a reduction in the average weekly feed consumption during the dietary regulation period. After the end of the regulated feeding period and the start of free feeding, a highly significant superiority was observed in the regulated treatments compared to the control treatment in terms of feed consumption and feed conversion efficiency. This is attributed to the fact that regulated feeding for broiler chickens during early ages increases gastrointestinal activity through the slow passage of feed material, allowing nutrients to be exposed more extensively and facilitating absorption cell activity, which improves nutrient absorption and increases the benefits derived from them, thereby enhancing feed conversion efficiency. It may also be attributed to the fact that regulated feeding for broiler chickens leads to physiological and anatomical changes in the digestive system, increasing the size of the digestive system, the capacity to store nutrients, an increase in the surface area for absorption, and greater exposure of nutrients to absorption cells, thus enhancing nutrient utilization and increasing feed consumption after the end of the regulated period [20]. The improvement in feed conversion efficiency and feed consumption rate is a result of the increased size of the digestive system [21]. Additionally, it is attributed to the fact that broiler chickens with regulated feeding achieved significant differences in the relative weights of the digestive system organs when compared to broiler chickens with free feeding, which positively reflects on feed consumption rates and improves feed conversion efficiency, as the increase in the size of the digestive system enhances the surface area for absorption [6].

Table 5 shows the effect of temporal dietary rationing on the logarithmic counts of Lactobacilli and E. Coli (cfu/g), where a significant superiority was observed in favour of the rationing treatments in the logarithmic counts of beneficial bacteria of the intestinal contents and a significant decrease in the logarithmic counts of pathogenic bacteria, This is attributed to the improvement of anaerobic bacteria due to the increase in the size of the digestive tract, its parts and intestines, improvement in digestion and storage processes in the gizzard for the standardized treatments, significant improvement in digestion and absorption processes in the intestine due to the increase in the surface area for absorption and the longer survival of nutrients in the gastrointestinal tract and intestines, and significant improvement in the synthesis of fermentation products by lactobacilli bacteria, which produces lactic acid that helps in inhibiting the multiplication of pathogens, This agrees with the opinion [22].

It may be attributed that metered feeding of broiler chickens altered the microbial composition of the ideal and cecal portions of the GI tract, leading to an increase in the logarithmic numbers of Lactobacilli bacteria as confirmed by [23].

1- Achieving significance in all production traits (final body weight, cumulative weight gain, cumulative feed consumption rate, cumulative feed conversion efficiency, production index values)

2- Achieving significance in carcass traits (hot carcass weight, clearance ratio with or without edible viscera, relative weights of the main segments, breast, thighs, heart, liver, and hindquarters)

3- Significant increase in the logarithmic numbers of beneficial bacteria, Lactobacilli, and a decrease in the numbers of harmful pathogenic bacteria, E. Coli.

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